REPORT DOCUMENTATION PA

AFRL-SR-BL-TR-98-
0211

Public reporting burden for this collection of information is estimated to average 1 hour per re... gathering and maintaining the data needed, and completing and reviewing the collection of inf... collection of information, including suggestions for reducing this burden, to Washington Headc... Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Bu... ing data sources, ...er aspect of this ..., 1215 Jefferson ...303.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1997	Final 9/1/93 - 8/31/97

4. TITLE AND SUBTITLE
Topics in Astrophysical Fluid Dynamics

5. FUNDING NUMBERS
F49620-93-1-0457
G

6. AUTHOR(S)
Edward A. Spiegel

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
The Trustees of Columbia University
in the City of New York
351 Engineering Terrace, MC 2205
1210 Amsterdam Avenue
New York, NY 10027

8. PERFORMING ORGANIZATION REPORT NUMBER
CAL 2723

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Office of Scientific Research
Building 410
Bolling AFB, DC 20332-6448
nm

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release,
distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The thesis work of Alex Casti and Orkan Umurhan has been supported on this grant. Casti is in the Columbia University Department of Applied Physics and Umurhan is in the Astronomy Department. Partial support also went for the thesis work of Phillip Yecko, who received his PhD in Astronomy and is now working in the Physics Department of the University of Florida.

19980311 090

14. SUBJECT TERMS
Astrophysical Fluid Dynamics

15. NUMBER OF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRAC
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

CAL-2723

Air Force Office of Scientific Research

Augmentation Awards for Science and Engineering Research Training

FINAL TECHNICAL REPORT FOR F49620-93-1-0457

Submitted to:

Dr. Henry R. Radoski
Program Manager
Air Force Office of Scientific Research
Building 410
Bolling AFB, DC 20332-6448

Submitted by:

The Trustees of Columbia University
in the City of New York
Box 20, Low Memorial Library
New York, New York 10027

Prepared by:

Columbia Astrophysics Laboratory
Departments of Astronomy and Physics
Columbia University
538 West 120th Street
New York, New York 10027

Co-Principal Investigator:

Edward A. Spiegel
Rutherfurd Professor of Astronomy

Title of AASERT Proposal: **Topics in Astrophysical Fluid Dynamics**

Agency Contract Number **F49620-93-1-0457**

Report Period 1 Septemmber 1993 – 31 August 1997

November 1997

AASERT FINAL REPORT

"Topics in Astrophysical Fluid Dynamics"

Edward A. Spiegel, Principal Investigator

Award number: F49620-93-1-0457

Personnel

The thesis work of Alex Casti and Orkan Umurhan has been supported on this grant. Casti is in the Columbia University Department of Applied Pysics and Umurhan is in the Astronomy Department. Partial support also went for the thesis work of Phillip Yecko, who received his Ph. D. in Astronomy and is now working in the Physics Department of the University of Florida.

Alex R. Casti

Casti worked for a time on a project in nonlinear stability theory, described in a previous report, but received a setback in the form of the appearance of a related work in the literature. He then attended the summer program in geophysical fluid dynamics in Woods Hole, where he began work on thermohaline convection in collaboration with N.J. Balmforth, a former participant in the parent grant. Thermohaline convection is a form of doubly diffusive convection and is thus a simple version of magnetoconvection. Both dissolved salt and magnetic fields can affect the local bouancy of a fluid, but dissolved salt, being represented by a scalar field, is somewhat easier to deal with mathematically and some interesting progress is possible. This form of convection will also occur in the cores of certain stars, including the sun, in the course of their evolution, the role of dissolved salt being taken by helium in the stellar case. In that case, it is called semiconvection. Two papers have been written with Balmforth on this project and submitted for publication.

To round out his dissertation, Casti has been working on the gravitational instability of two interpenetrating, barotropic fluids interacting only through gravity. If there is an initial relative velocity between the two fluids, small perturbations are unstable at all wavenumbers in some range of Mach numbers. By exploiting the analogy between this problem and the two-stream instability of plasma physics, it has been possible to demonstrate the existence of negative energy modes from the indefiniteness of the energy functional. This allows for explosive nonlinear growth even in situations for which the linear theory predicts absolute stability. Casti will present a poster on this work, in collaboration with P.J. Morrison of Fusion Institute of the University of Texas, at the next meeting of the AAS. It is expected that Casti will defend his dissertation in the present academic year.

Orkan M. Umurhan

Umurhan has extended his earlier calculations of acoustic instability in stellar atmospheres to the nonlinear regime. He now has a complete discussion of such instability with extensive analytical and numerical results. In his study he has examined the instabilities of nonadiabatic acoustic modes in plane parallel atmospheres where the source of nonadiabaticity is thermal conduction. Since he has adopted a constant coefficient of thermal conduction, this instability is not the conventional κ-mechanism.

Umurhan has adopted a polytropic static state in which the density is related to the pressure by a polytropic index m. He has solved the resulting fourth order eigenvalue problem describing perturbations by a variety of asymptotic and numerical methods. He finds that disturbances are unstable under a variety of parameter regimes including conditions where the background polytrope is either super- or subadiabatic. Two main instabilities emerge and one of them resembles the thermoacoustic engine familiar in industrial applications. He has also gone on to develop a weakly nonoinear theory of the unstable acoustic modes. Umurhan will present a poster on this work at the forthcoming AAS meeting.

In the course of coupling the acoustic modes to the convective modes, Umurhan has made an interesting contribution to convective pattern theory in the low Prandtl number limit. (The Prandtl number is the ratio of viscosity to conductivity and, though it is of order unity in most laboratory experiments, it is quite small in stars.) In particular, he has derived a new nonlinear pattern equation for fixed-flux convection, which generalizes the one used for laboratory convection. Two papers on this work are in preparation. This work will complete Umurhan's dissertation research and he is engaged in the process of preparing his thesis for the final defense.